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Anomalies of the Genus *Paralichthys* (Pisces, Bothidae), Including an Unusual Double-Tailed Southern Flounder, *Paralichthys lethostigma*¹

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Abstract

A double-tail flounder, *Paralichthys lethostigma*, and six instances of pigment anomalies and associated abnormalities are reported for the genus *Paralichthys* from North Carolina. Caudal structure of the double-tailed *P. lethostigma* is described. Analysis of radiographs reveal no manifest abnormalities for incomplete ambicolorates. However, total ambicolorates with incomplete eye migration and hooked dorsal fin show atypical osteological structures in the orbital region. Theories concerning inducement of ambicoloration are reviewed.

Introduction

Numerous pigment anomalies and associated deformities in Pleuronectiforme fishes have been reported (Dawson, 1964, 1966, 1971), and many theories explaining ambicoloration have been advanced. Norman (1934) reviewed the early conjectures: exposure to prolonged periods of light on the blind side; prolonged pelagic stage, subjecting the future blind side to prolonged light; germinal factors; disruption of embryonic transformation mechanisms; mutation, resulting in secondary bilateral symmetry; his own view and apparently that of Hubbs and Hubbs (1945) was that "ambicoloration really represents variation in the direction of the original bilaterally symmetrical condition of the ancestors of the flatfish." DeVeen (1969) summarized recent diverse theories: innate vs. acquired pigment deformities; strong light intensity at metamorphosis; susceptibility of larval hatching in total darkness; population density during metamorphosis; temperature during larval development; and low food levels during larval rearing. These theories relate to the early life history of the fish, especially preceding metamorphosis. Houde (1971) experimentally noted for *Achirus lineatus* that environmental conditions before metamorphosis

may cause pigment abnormalities, whereas DeVeen (1969) indicated that abnormal coloration in plaice, *Pleuronectes platessa*, may develop throughout its life.

Ambicolorate *P. lethostigma* (Gray, 1960) and *P. dentatus* have been previously noted from North Carolina waters (Deubler and Fahy, 1958; Gudger, 1935; Hussakof, 1914; White and Hoss, 1964). These included specimens with the hooked dorsal fin (Deubler and Fahy, 1958; Gray, 1960) and the ambicolorate condition without associated anomalies (Hussakof, 1914; Gudger, 1935; White and Hoss, 1964). We will note several pigment and structural abnormalities, including a double-tailed specimen, of various paralichthid flounders captured in North Carolina waters between 1960 and 1972.

Study Material

Six bothid flounders within the genus *Paralichthys* captured in trawls and gill nets showed various states of ambicoloration, incomplete eye migration, hooked dorsal condition, and a double tail. These were: *P. dentatus* UNC 3495, 237 mm, 294 g, trawl, M/V Edith M, 12 Nov. 1960; UNC 4792, 337 mm SL, 583 g, trawl, M/V Edith M, 19 Oct. 1968; *P. lethostigma* UNC 6153, 244 mm SL, 280 g, trawl, M/V Edith M, 19 Oct. 1968; UNC 4794 (2), 252 mm SL, 277 g; 350 mm SL, 841 g, gill net, C. Pollard, 13 through 23 Oct. 1969; UNC 6154, 303 mm SL, 875 g, gill net, 15 Oct. 1970; UNC 6195, 234 mm SL, 187 g, trawl, J. Richardson, July 1971.

Description of Specimens

• *Double-tail*. Chabanaud (1935) noted an atypical bothid, *Zeugopterus punctatus*, with an unusual tail. From his figure, the caudal fin appeared as a singular structure, whereas posterior protrusion of the dorsal and anal elements gave the tail an unusual appearance. *Paralichthys lethostigma*, UNC 6154, is to our knowledge the first paralichthid flounder with a double tail to be reported. Okada (1950) has reported this condition for a field-caught coffer

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FIG. 1. Caudal fin of a shark, showing the dorsal fin and the caudal fin. The dorsal fin is located on the left side of the image, and the caudal fin is on the right side. The caudal fin is deeply forked, with the upper lobe slightly curved upwards. The lower lobe is broader and has a more rounded tip. The skin on the body of the fish is covered in small, bumpy scales.

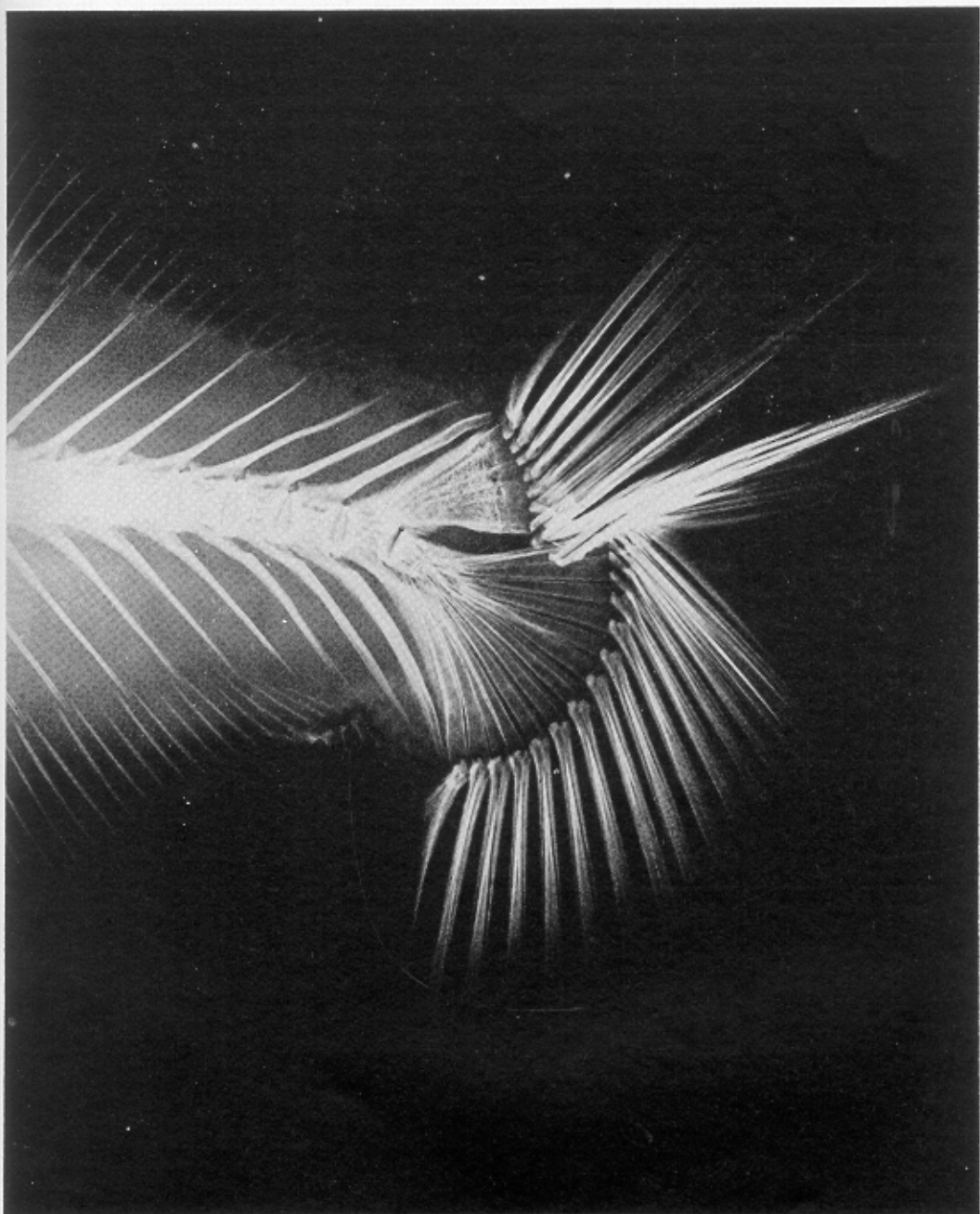


FIG. 1a, 1b. Caudal structure of the double-tailed *Paralichthys lethostigma*. Radiograph of same specimen.

fish, *Ostracion farnasini*, family Ostraciontidae. He found that both tails contained the usual 10-ray complement with three extra bony pieces located between the tails; our condition is more drastic (Fig. 1a, b). We followed the terminology of Woolcott et al. (1968) in describing the caudal fin structure. We found that the penultimate vertebrae had a distorted hourglass shape. The neural spine of the penultimate vertebrae, usually modified into the first epural element supporting a fin ray, appeared to be a massive structure making up the upper caudal fin. It consisted of five separate elements demarcated by fissures supporting eight to nine epaxial fin rays. The haemal

spine of the penultimate vertebrae appeared unaffected. There were 16 fin rays of the upper caudal fin; eight to nine of them were supported by the penultimate neural spine; seven to eight rays appeared free or articulated with the dorsal edge of the lower caudal's first epural.

Superficially, the lower caudal fin appears natural (Fig. 1). The caudal fin of a typical *P. lethostigma* has two distinct autogenous epurals supporting three to four epaxial rays and one autogenous hypural supporting two hypaxial rays. Either our double-tailed specimen lacks autogenous epurals or these elements form part of the upper caudal fin in conjunc-

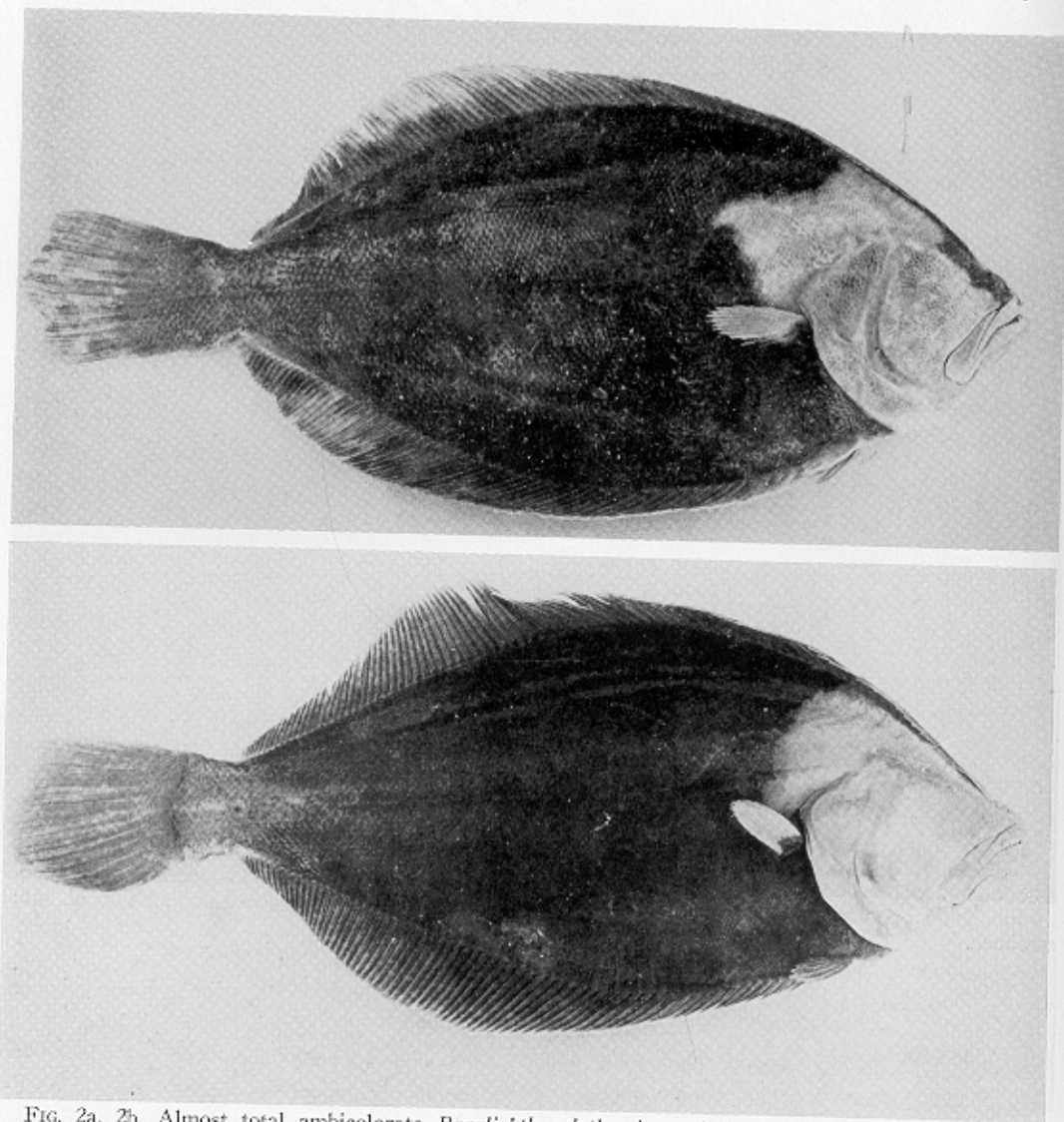


FIG. 2a, 2b. Almost total ambicolorate *Paralichthys lethostigma* (a), *P. dentatus* (b).

tion with the penultimate neural spine. One autogenous hypural is developed and supports three fin rays. The epural and hypural elements of a typical *P. lethostigma* tail are distinctly differentiated; six epurals support six epaxial rays and five hypurals support five hypaxials. Our anomalous caudal structure lacks clear division between the epural and hypural elements. There appears to be nine epural-hypural elements supporting 12 to 13 fin rays, and the first epural probably supports four to five epaxial rays. The epaxial and hypaxial rays of this lower caudal fin appear to total 17.

• *Ambicolorates*. Many examples showing degrees of ambicoloration and the occurrence of associated anomalies in relation to the extent of blind-side pigmentation have produced a "classification" of pigment anomalies (Dawson, 1962). In terms of this classification, the remaining anomalous specimens consist of two examples of a Type B anomaly (almost total ambicoloration) and four examples of a Type

D anomaly (total ambicoloration, incomplete eye migration, and hooked dorsal fin).

Type B anomaly. Blind-side pigmentation (Fig. 2a, b) of the two congeneric paralichthid species (UNC 4792, 6153) was similar and resembled that of the anomalous *P. dentatus* noted by Gudger (1935). *P. dentatus* (UNC 4792) exhibited oscillated patterns on the blind side similar in shape and in location to those on the eyed side. Pigmentation was wanting on the right pectoral fins of *P. lethostigma* (UNC 6153), whereas approximately 20 per cent of the basal portion of the right pectoral fin of the *P. dentatus* was pigmented. Pectoral fins were longer on the eyed side of both species, with no variation toward symmetry (Norman, 1934). Radiographs revealed no abnormalities in body skeletal structures.

Type D anomaly. The blind sides of our Type D paralichthids (UNC 3495, 4794 (2), 6195), which exhibited incomplete eye migration and hooked dorsal fin, were totally pigmented except for distal portions (15-80 per

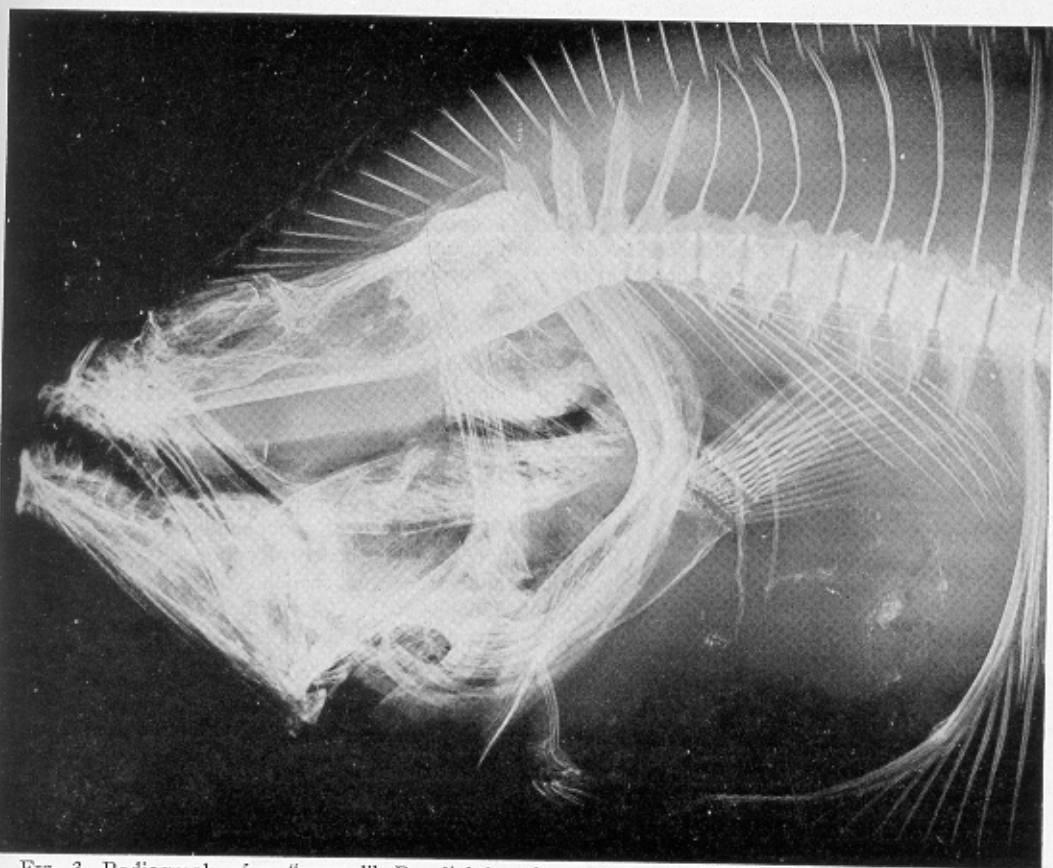


FIG. 3. Radiograph of a "normal" *Paralichthys dentatus* flounder.

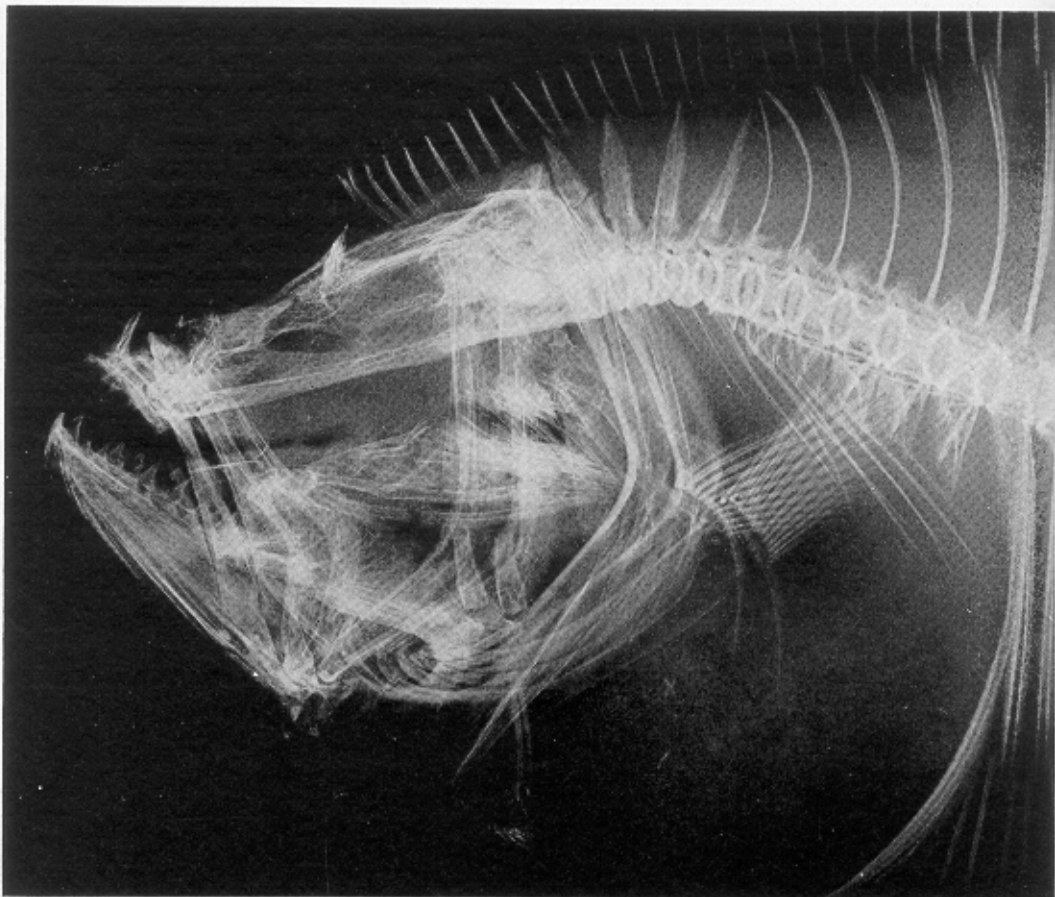


FIG. 4. Radiograph of a *Paralichthys lethostigma* with total ambicoloration, incomplete eye migration, and hooked dorsal fin. Note the unusual rearward projection of the oblique crest of the left frontal bone.

cent) of their right pectoral fin. Examination of fin lengths revealed no variation toward symmetry. Although the dorsal fins were not developed anteriorly and persisted as hooks, all ray counts were within the ranges noted by Gutherz (1967).

Comparisons of radiographs of a "normal" (Fig. 3) and a Type D flounder (Fig. 4) show great differences in the structure of the oblique crest of the left frontal bone, which forms the posterior boundary of the right orbit. A distinct dorsal rearward protrusion of this crest occurred in all of our Type D anomalies. Norman (1934) found that the frontals appear in the final position after eye migration is complete. It then follows that bone structure associated with the right orbit would be modified by any abnormality of the orbit's position. Examining the radiographs of the Type D specimens, we could not see the complete out-

lines of the frontals and prefrontals clearly enough to determine possible variation toward symmetry. The dorsal pterygiophores of Type D specimens terminated at the oblique crest (Fig. 4) whereas they usually continue anteriorly past the orbit (Fig. 3). The number of dorsal rays and pterygiophores were counted from the first neural spine anteriorly in four anomalous and two "normal" flounders (UNC 2765, 4670). The latter had pterygiophore counts of 10 and 11 respectively; each pterygiophore supported one ray. The Type D specimens exhibited: 10 pterygiophores supporting 10 rays (*P. lethostigma*; UNC 4794, 6195); nine pterygiophores and 10 rays (*P. lethostigma*; UNC 4794); and nine pterygiophores, each supporting a ray (*P. dentatus*; UNC 3495). All pterygiophores were crowded, and the above counts suggest that the median fin ray number was determined before complete

eye migration. Smith and Fahay (1970) reported a 12.14-mm *P. dentatus* with a median-fin formula within the adult range. Their figure (Pl. 11, p. 21) of a 12.60-mm (SL) *P. dentatus* with an adult fin formula exhibited an eye position similar to that of our adult anomalies. Hence, in the usual paralichthid specimen, dorsal fin growth without increase in numbers of fin rays continued forward to its final position, if the eye migration was clear of the median line. Forward growth of the dorsal fin in our Type D flatfish was inhibited by the dorsal crest protrusion of the left frontal bone, but counts of dorsal pterygiophores and accompanying rays seem unaffected.

Observations

Radiographic examination of our material indicates that skeletal damage does not cause the ambicoloration or hooked condition in adult *P. dentatus* and *P. lethostigma*. We must continue to agree with Gudger and Firth's (1936) rule that whenever the lower surface is colored like the upper or when about one-fourth to a third of the head surface of the blind side is colored, the rotating eye will not complete migration and the anterior dorsal fin will be hooked.

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